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# Temporal Connectives in a Discourse Context

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## Abstract

We examine the role of temporal connectives in multi-sentence discourse. In certain contexts, sentences containing temporal connectives that are equivalent in temporal structure can fail to be equivalent in terms of discourse coherence. We account for this by offering a novel, formal mechanism for accommodating the presuppositions in temporal subordinate clauses. This mechanism encompasses both *accommodation by discourse attachment* and *accommodation by temporal addition*. As such, it offers a precise and systematic model of interactions between presupposed material, discourse context, and the reader's background knowledge. We show how the results of accommodation help to determine a discourse's coherence.

## 1 Introduction

We focus on aspects of the discourse behaviour of the temporal connectives *before*, *after* and *when*. In particular, we note that discourse context can cause sentences which are equivalent in temporal structure to fail to be equivalent in terms of discourse coherence. We attempt to explain why context can have this effect. The explanation hinges on the differing presuppositions posted by the differing connectives, and on the novel mechanism whereby background knowledge determines how they are accommodated into the discourse structure during interpretation.

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## 2 Temporal Equivalence and Discourse Incoherence

First, then, consider the following actual sequence of states and events: in the UK in November 1992, some right-wing Tory backbench MPs were objecting to government policy over the treaty of Maastricht, and threatened to vote against it; the Prime Minister, a Mr John Major, offered them a variety of concessions to win them back, in what the press termed a "charm offensive"; the MPs responded by voting with the government. Call this course of events  $E_1$ .

We can combine descriptions of the main eventualities in several ways, to reflect the right temporal structure, but only some of these seem pragmatically appropriate: consider in particular these possible descriptions of  $E_1$  involving the connectives *before*, *after* and *when*:

- (1) The backbenchers were in revolt.
- (2)
  - a. They were pacified after Major launched a charm offensive.
  - b. ?Major launched a charm offensive before they were pacified.
  - c. They were pacified when Major launched a charm offensive.
  - d. ?Major launched a charm offensive when they were pacified.

There are at least two apparent anomalies, which require explanation. First, one might expect that (2a) and (2b) would be *temporally equivalent*, both describing  $E_1$ ; why, then, does (2b) apparently lead to discourse incoherence? Secondly, it has been argued that *A when B* permits many possible temporal relationships between the eventualities denoted by *A* and *B* (cf. Moens and Steedman 1988); it's for this reason that (2c) can be interpreted as denoting  $E_1$ ;

but given this permissiveness, why is (2d) not as acceptable as (2c)?

### 3 The basic explanation: temporal presuppositions

The basic explanation for the inappropriateness of (2b) and (2d) is actually quite simple. Sentences containing temporal connectives are *presuppositional*: the temporal clause introduces an eventuality that must be presupposed to have occurred, for the sentence as a whole to have a truth-value (cf. Heinämäki 1972; Karttunen 1973). If the presupposed eventuality is not already in the reader's model of the discourse context, she must add it: a process known as *accommodation* (cf. Lewis 1979). Our view is that the discourse behaviour of temporal connectives is to be explained as follows. In the discourse context where we are describing  $E_1$ , and have uttered (1), the way presuppositions are accommodated depends on the reader's background knowledge; our inappropriate discourses are precisely those where accommodation ultimately leads to discourse incoherence. In particular, the presupposed eventuality from *they were pacified* cannot be accommodated in the previous context provided by (1), and must therefore be given further treatment.

A presuppositional explanation stands in contrast to the classical accounts of temporal structure built upon Kamp's (1981) Discourse Representation Theory (DRT) (cf. Partee 1984; Hinrichs 1986). On both these accounts, subordinate clauses, such as those introduced by temporal connectives, update the current reference time, and the main clause is then interpreted with respect to that reference time. However, no constraint is placed on the relationship between the current reference time, and the new reference time supplied by the subordinate clause. And so no anomaly will be detected in (2b): a relation of temporal progression between (1)'s reference time and the new reference time for *they were pacified* will be added to the DRS. Thus, the incoherence of (2b) in the discourse context supplied by (1) remains unexplained. This is only to be expected, since the construction of discourse representation structures is syntax-driven, and does not attempt to capture the interactions with world knowledge which seem relevant here.

So, although it promises to go further, the basic presuppositional explanation raises deeper questions. Why can't *they were pacified* be accommodated into the discourse context provided by (1)? What knowledge is it that leads to failure in this case, but success when we try to accommodate *Major launched a charm offensive*? Intuitively, the reader's background knowledge affects accommodation: world knowledge (WK) and pragmatic maxims can make accommodation impossible.<sup>1</sup> So to make

the basic explanation precise, we need a formal theory of how such knowledge constrains accommodation.

Van der Sandt and Geurts (1991) provide a formal mechanism for presupposition accommodation in DRT, but they provide only informal heuristics that stipulate how background knowledge might affect the process. We extend their ideas, by providing a formal specification of those heuristics. We embed their account of accommodation in DICE (*Discourse and Commonsense Entailment*) (Lascarides and Asher 1991, 1993; Lascarides et al 1992). DICE permits us to model the interactions between linguistic knowledge (LK) and WK which lead to the assignment of discourse coherence relations between propositions introduced by text segments, and temporal-causal relations between the eventualities they denote. The primary proposal is that the accommodation of presuppositions from temporal subordinate clauses be modelled as discourse attachment, so that accommodation is properly constrained by the reader's background knowledge. Let us call this basic idea *accommodation by discourse attachment* (ADA).

Although we contrasted presuppositional accounts with classical DRT approaches, there are clear instances where a temporal subordinate clause has no special rhetorical role in a discourse, but acts instead as a temporal adverb. Such instances are less problematic for classical approaches than cases like (1,2b), but at the same time would pose problems for an account of temporal connectives that relied exclusively on ADA. Consider texts (3,4a) and (3,4b), modified from Hamann (1989:83–84):

- (3) I'm not a useless driver.  
(4) a. I could drive before you were born.  
b. ?You were born after I could drive.

(3,4a) and (3,4b) are temporally equivalent, but only the former is discourse coherent. If ADA were the whole story, then (3,4a) would be analysed as *incoherent*, since no rhetorical connection can be located between the speaker's driving ability and the hearer's birth. But (3,4a) is coherent, because the reference to birth is simply functioning as an adverbial, locating the starting point of driving in the distant past.

We will therefore suggest that the primary proposal, where accommodation involves discourse attachment, must leave room for the possibility that presupposed eventualities can be directly added to a discourse context, without any discourse relations being involved. Let us call this latter idea *accommodation by temporal addition* (ATA). Our treatment of temporal connectives combines ADA and ATA; it thus effectively deals with temporal subordinate clauses by bringing together the presuppositional account

of the presuppositions of the counterfactual uses of *before*, first observed by Heinämäki (1972:139). We have no space to discuss these here, unfortunately.

<sup>1</sup> Background knowledge is also essential to the expla-

and the classical DRT account. We now briefly review the two basic ingredients of the account: A mechanism for presupposition accommodation, and a theory of discourse attachment.

#### 4 A mechanism for presupposition accommodation

Van der Sandt and Geurts (1991) assume that presuppositions are anaphora with semantic content. They distinguish cases in which presuppositions are 'cancelled' from those in which they are 'realised'. The cancelling of presuppositions is explained away as *binding* of anaphora. In other words, cancellation occurs when there is an appropriate antecedent in the reader's model of the discourse context that can be identified with the presuppositional material in the clause currently being processed. For example, in sentence (5), the presupposition normally associated with *his wife*—which is that John has a wife—is cancelled by the conditional clause *If John is married*, which produces an antecedent in the reader's model of the context to which *his wife* can be bound.

- (5) If John is married, then his wife will be happy.

The realising of presuppositions is handled through *accommodation*. Suppose there is no appropriate antecedent in the reader's model of the discourse context to which the presuppositional material can be bound. In that case, the reader attempts to *add* the material to the discourse context, subject to certain constraints; for example, that the result of the addition must be logically consistent.

Sentences containing presuppositions are represented as a sentence DRS (or SEDRS) which is a triple containing: a set of discourse markers; a set of DRS conditions; and a (possibly empty) set of SEDRSs. The latter set demarcates those parts of the sentence that are presupposed, and that must therefore be bound or accommodated to the preceding discourse context; the former sets are those parts of the sentence that aren't presupposed. Binding is achieved through *identifying* the presupposed discourse referents with those already in the context. Accommodation is achieved through *adding* the presuppositional material to part of the discourse context; this process is subject to certain informal heuristic constraints.

Van der Sandt and Geurts provide a definition of subordination involving SEDRSs which extends that of traditional DRT. A hierarchical structure is thus defined, and an order of priority for dealing with presuppositions can then be specified. The order is: try binding at a lower level; binding at a higher level; accommodating at a higher level; accommodating at a lower level.

#### 5 A mechanism for discourse attachment

As mentioned before, we wish to enrich van der Sandt and Geurts' process of accommodation by using a general theory of discourse attachment; by doing this we provide a formal specification of the constraints on accommodation imposed by the reader's background knowledge. The general theory of discourse attachment we will use is DICE.

DICE rests on a semantically-based theory of discourse structure called Segmented DRT (SDRT) (cf. Asher 1993). SDRT starts with traditional DRSS (cf. Kamp 1981), but goes on to assume with Grosz and Sidner (1986) that candidate discourses possess hierarchical structure, with units linked by discourse relations modelled after those proposed by Hobbs (1985) (cf. also Mann and Thompson 1987, Scha and Polanyi 1988). The resultant representations are called segmented DRSS (or SDRSS). Here, we use five discourse relations: *Narration*, *Background*, *Result*, *Explanation* and *Elaboration*. The latter two are subordinating relations, and the proposition introduced by the current sentence can attach only to the previous constituent of the SDRS for the text so far, or constituents it elaborates or explains.

SDRT defines those parts of an SDRS that are available for attachment with new information via a discourse relation. DICE is a logical theory of discourse attachment, which explains how to infer *which* discourse relation to use. DICE specifies rules that represent the reader's background knowledge, and these interact via the nonmonotonic logic Commonsense Entailment (CE) proposed by Asher and Morreau (1991), to determine the discourse relations between propositions introduced in a text, and the temporal relations between the eventualities they describe. We here indicate some plausible rules and the inference patterns validated by CE, and demonstrate how they are involved in discourse attachment.

The rules that capture WK and LK allow us to reason about the value of the update function  $\langle \tau, \alpha, \beta \rangle$ , meaning "the representation  $\tau$  of the text so far (of which  $\alpha$  is already a part) is to be updated with the representation  $\beta$  of the current clause via a discourse relation with  $\alpha$ ". Let  $e_\alpha$  be a term referring to the main eventuality described by the clause  $\alpha$ ; and let  $revolt(b, e_\alpha)$  mean that this eventuality is a backbencher revolt. As usual, we represent the defeasible connective as a conditional  $>$ . The following schemas are some rules for calculating implicatures:<sup>2</sup>

- **Narration:**  
 $\langle \tau, \alpha, \beta \rangle > Narration(\alpha, \beta)$
- **Axiom on Narration:**  
 $Narration(\alpha, \beta) \rightarrow e_\alpha < e_\beta$

<sup>2</sup> $e_\alpha$  abbreviates  $me(\alpha)$ , which is formally defined in Lascarides and Asher (1993). The indefeasible rules are necessary; we have here omitted the  $\square$  operators.

- **Result:**  
 $\langle \tau, \alpha, \beta \rangle \wedge \text{cause}(e_\alpha, e_\beta) > \text{Result}(\alpha, \beta)$
- **Axiom on Result:**  
 $\text{Result}(\alpha, \beta) \rightarrow e_\alpha \prec e_\beta$
- **States Overlap:**<sup>3</sup>  
 $\langle \tau, \alpha, \beta \rangle \wedge \text{state}(e_\alpha) > \text{overlap}(e_\alpha, e_\beta)$
- **Background:**  
 $\langle \tau, \alpha, \beta \rangle \wedge \text{overlap}(e_\alpha, e_\beta) > \text{Background}(\alpha, \beta)$
- **Axiom on Background:**  
 $\text{Background}(\alpha, \beta) \rightarrow \text{overlap}(e_\alpha, e_\beta)$
- **Revolt Law:**  
 $\text{revolt}(b, e_1) \wedge \text{pacified}(b, e_2) > \neg \text{overlap}(e_1, e_2)$
- **Charm Law:**  
 $\langle \tau, \alpha, \beta \rangle \wedge \text{charm}(a, b, e_1) \wedge \text{pacified}(b, e_2) > \text{cause}(e_1, e_2)$
- **Causes Precede Effects:**  
 $\text{cause}(e_2, e_1) \rightarrow \neg e_1 \prec e_2$

Narration, Result and Background represent defeasible LK, and the axioms on them indefeasible LK. In particular, Narration and its axiom let us say that by default, the descriptive order of events matches their temporal order in interpretation. The Revolt Law and the Charm Law are slightly different kinds of knowledge. The former is pure WK; normally an entity isn't revolting and pacified at the same time. The latter is a mixture of LK and WK; given that the clauses are discourse-related somehow, the events they describe must normally be connected in some temporal-causal relation; here, charmings normally stand in a causal relation to the state of pacification. That Causes Precede their Effects is indefeasible WK.

We also assume that certain discourse relations impose various constraints on the topic structure of the discourse (cf. Asher 1993, Lascarides and Asher 1993). For example, Distinct Common Topic for Narration and Background states that if  $\alpha$  and  $\beta$  form a narrative or background, then they must have a distinct, common (and perhaps implicit) topic  $\gamma$ :

- **Distinct Common Topic for Narration and Background:**  
 $\text{Narration}(\alpha, \beta) \vee \text{Background}(\alpha, \beta) \rightarrow (\exists \gamma)(\gamma \neq \alpha \wedge \gamma \neq \beta \wedge \gamma \downarrow \alpha \wedge \gamma \downarrow \beta)$

CE supports the three patterns of nonmonotonic inference that are relevant here. The first is Defeasible Modus Ponens: if one default rule has its antecedent verified, then its consequent is defeasibly inferred. The second is the Penguin Principle: if there are conflicting default rules that apply, and the antecedent of one entails that of the other, then the consequent of the more specific rule (the former one) is defeasibly inferred. The third is the Nixon Diamond: no conclusion is drawn if there are conflicting default rules that apply whose antecedents aren't logically related.

<sup>3</sup>There are two versions of this rule; the other covers the cases where the second clause is stative.

To see how the rules work, consider (6) and (7).

- (6) The backbenchers were in revolt. Major launched a charm offensive.
- (7) ?The backbenchers were in revolt. They were pacified.

In interpreting (6) we try to attach the second sentence to the first (so  $\langle \alpha, \alpha, \beta \rangle$  holds, where  $\alpha$  and  $\beta$  are respectively the logical forms of the first and second clauses). *Two* of our defeasible laws apply: Narration and States Overlap. They conflict, but States Overlap is more specific. So by the Penguin Principle,  $\text{overlap}(e_\alpha, e_\beta)$  is inferred. So Background, which also conflicts with Narration, applies. By the Penguin Principle again,  $\text{Background}(\alpha, \beta)$  is inferred, since Background is more specific.<sup>4</sup> Thus (6) is discourse coherent, in the precise sense that  $\beta$  can be attached to  $\alpha$  with a discourse relation; we have also found that the state of revolt overlapped with the event of Mr Major's charm offensive.

Now consider (7). The appropriate knowledge base in the analysis of (7) satisfies States Overlap, the Revolt Law and Narration. The first two of these conflict, but their antecedents aren't logically related. For note that unlike the Charm Law, the Revolt Law does *not* require the clauses concerned to be discourse connected somehow: being pacified and being in revolt don't normally overlap, *regardless* of whether they are connected or not. Because there is conflict among defeasible rules with unrelated antecedents, a Nixon Diamond crystallises. Consequently, no temporal or discourse relation can be inferred, and so no representation of (7) is constructed, leading to discourse incoherence.

## 6 The proposal: accommodation by discourse attachment

The basic explanation of the defectiveness of (2b,d) relied on the idea that temporal clauses are presupposed; even though (2b) may be taken to refer to the same temporal structure  $E_1$  as (2a), it is pragmatically inappropriate. In making this explanation more precise, we wish to characterise presupposition accommodation as a process of discourse attachment; and failure to accommodate thus involves failure to attach, or, in other words, (local) discourse incoherence. In the (1,2) examples, failure to attach at a particular site can be fatal, as we will see shortly.

More precisely: (i) Subordinate temporal clauses are presupposed. (ii) If binding the presupposition fails, then it must be accommodated. (iii) If accommodation is necessary, then it is assumed in the first instance that the proposition introduced by the subordinate clause plays a rhetorical function in the dis-

<sup>4</sup>Although the double application of the Penguin Principle, as in (6), is not valid in general, Lascarides and Asher (1993) show that for the particular type of case considered here, CE validates it.

course, and so accommodation proceeds via discourse attachment. The presupposition must be attached to the discourse structure by a discourse relation, before the DRS of which it is a sub-part is attached. (iv) In that case, the presupposition can be discourse related to: either prior discourse or the DRS corresponding to its matrix clause. (v) If, on the other hand, accommodation via discourse attachment fails, then the assumption that the subordinate clause plays a rhetorical role is defeated, and accommodation is attempted via the *addition* of the presupposed event to the discourse context. (vi) If the presupposition is successfully dealt with, an attempt is then made to discourse-relate the resulting constituents of the discourse, using the reader's background knowledge.<sup>5</sup>

So, presuppositions can lead to incoherence in at least four ways. First, binding may be successful, but the resultant constituents of the discourse may fail to attach together (as in (3,4b)). Secondly, binding may fail, while ADA is successful, and then the resultant constituents of the discourse may fail to attach together (as in (1,2b)). Thirdly, binding and ADA may fail, while ATA is successful—as in (3,4a)—but then, in contrast to (3,4a), the resultant constituents may fail to attach together. Finally, binding and both types of accommodation may fail.

To reflect this process of interpreting temporal connectives in a discourse context, we propose that discourse attachment be split into four stages, of which the third has three main parts:

1. We build the sentence DRS (or SEDRS) for the sentence containing the temporal connective.
2. We then calculate the temporal implicatures for the SEDRS, that arise from the temporal connective used, if there are any.
3. We then handle the presupposition: (a) We attempt to bind. If that fails, (b) we attempt accommodation, by attempting discourse attachment between available SDRSs and the third sub-part of the SEDRS (which corresponds to the presupposed clause). If the presupposition is bound or accommodated by discourse attachment, we go to (4). But if (b) fails, then (c) we attempt accommodation by adding the third sub-part of the SEDRS to an available SDRS, and if this is possible, we go to (4). If (c) fails, then we fail on the grounds of incoherence.
4. Attempt discourse attachment between the current DRS and available SDRSs. If attachment succeeds, go to (1) with the next sentence. If not, fail on the grounds of incoherence.

<sup>5</sup> Points (iii) and (iv) correspond to ADA; point (v) to ATA.

## 7 Temporal information from connectives

First of all, we register Hamann's (1989:76) observation that *before* and *after* operate on points by placing in the SEDRS the relevant precedence conditions on the points of time at which the eventualities are asserted to hold. We fold states into this picture by introducing a default 'inceptive' reading for temporal connectives; *conn* here varies over *before* and *after*; an eventuality is *incstate* if it's inceptive. That is, *incstate*( $e_\delta$ ) is true only if the time discourse referent  $t$  introduced in the DRS  $\delta$  is the time where  $e_\delta$  starts.

- **Inceptiveness with Connectives (IC1):**  
 $\beta = \text{conn}(\delta, \gamma) \wedge \text{state}(e_\delta) > \text{incstate}(e_\delta)$
- **Inceptiveness with Connectives (IC2):**  
 $\beta = \text{conn}(\delta, \gamma) \wedge \text{state}(e_\gamma) > \text{incstate}(e_\gamma)$

In words,  $\delta$  *before/after*  $\gamma$  normally entails that  $\delta$  and  $\gamma$  are to be interpreted inceptively, if either of them are stative.

It is suggested that *when* clauses, by contrast, do not implicate inceptiveness; indeed they do not have any special *temporal* implicatures (cf. Moens and Steedman 1988). However, it can be argued that *when* does have a *causal* implicature: it serves to restrict the kinds of contingency relationships that can hold between eventualities; in particular, it defeasibly cuts off one possibility:

- **No Cause:**  $\text{when}(\alpha, \beta) > \neg \text{cause}(e_\alpha, e_\beta)$

## 8 Worked examples

To demonstrate how the approach works, we here treat several types of cases involving presupposition accommodation: first, we deal with two pairs of cases where accommodation via discourse attachment succeeds; in one pair the result is coherent, and in the other it isn't. Then we will deal with a case where binding and accommodation by discourse attachment fail, but accommodation by temporal addition succeeds. Finally, we will deal with a case where the presupposition is bound. The coherent cases treated here are (1,2a) and (1,2c), involving *after* and *when* and (3,4a), involving *before*; the incoherent cases are (1,2b) and (1,2d), involving *before* and *when*, and (3,4b), involving *after*.

### 8.1 Discourse attachment with coherence

Consider text (1,2a):

- (1) The backbenchers were in revolt.
- (2) a. They were pacified after Major launched a charm offensive.

Let the logical representation of (1) be  $\alpha$ , and the SEDRS for (2a) be  $\beta_a$ ; note that the precedence condition  $t_3 < t_2$  is incorporated into the DRS for the matrix clause.

- ( $\alpha$ )  $[e_1, t_1][\text{revolt}(b, e_1), \text{hold}(e_1, t_1), t_1 \prec \text{now}]$   
 ( $\beta_a$ )  $\langle\{e_2, t_2\}, \{\text{pacified}(b, e_2), \text{hold}(e_2, t_2),$   
 $t_2 \prec \text{now}, t_3 \prec t_2\},$   
 $\langle\{e_3, t_3\}, \{\text{charm}(a, b, e_3), \text{hold}(e_3, t_3),$   
 $t_3 \prec \text{now}\}, \emptyset\rangle\rangle$

In the first stage of discourse attachment, we build the representation for  $\beta_a$  just given. In the second stage, we add its temporal implicatures. By IC1, we come to believe via Defeasible Modus Ponens that the state of pacification doesn't just hold at  $t_2$ ; it starts there.

In the third stage, we attempt to deal with the presupposed part of  $\beta_a$ . Let  $\gamma$  be the presuppositional clause corresponding to  $e_3$ , and  $\delta$  the matrix corresponding to  $e_2$ .  $\gamma$  will fail to bind to  $\alpha$ . Can it attach? We assume  $\langle\alpha, \alpha, \gamma\rangle$ , and so the line of reasoning is exactly that used for (6), and a *Background* relation holds between the revolt and the charm offensive. Once  $\gamma$  has been attached, we move on to the final stage of processing: we must attach the DRS which remains when  $\gamma$  has been deleted from it. Call this  $\epsilon$ .

- ( $\epsilon$ )  $[e_2, t_2][\text{pacified}(b, e_2), \text{hold}(e_2, t_2), t_2 \prec \text{now},$   
 $t_3 \prec t_2]$

The only open constituent in the SDRS built so far is  $\gamma$ , because the relation in the SDRS is *Background*( $\alpha, \gamma$ ). So we assume  $\langle\tau, \gamma, \epsilon\rangle$ , and find that Narration, States Overlap and the Charm Law apply. States Overlap conflicts with what has already been accepted via IC1. Furthermore, it conflicts with the Charm Law, which is more specific. So, *cause*( $e_3, e_2$ ) and *Narration*( $\gamma, \epsilon$ ) are inferred. By the causal relation, the antecedent to Result is now verified, and so *Result*( $\gamma, \epsilon$ ) is also inferred. So, in brief, the first state functions as background to the presupposed event, of which the second sentence's state is the result.

Of the versions of (2) involving the connective *when*, only one is coherent in the discourse context, and its analysis is very similar to that of (2a) just given.

- (1) The backbenchers were in revolt.  
 (2) c. They were pacified when Major launched a charm offensive.

Just as with (2a), the presupposed charm event is successfully accommodated with respect to the preceding discourse, and the main clause state of pacification is then attached as its result. There are two differences in the analysis: the semantics of *when* places no conditions in the matrix clause  $\delta$  on the temporal relation between  $e_2$  and  $e_3$ ; however, in the second stage of discourse attachment, further implicatures are added ( $\neg\text{cause}(e_2, e_3)$ : the pacification did not cause the charming). In spite of these temporal differences, the final discourse structure is the same.

## 8.2 Discourse attachment without coherence

Now, let us consider two cases where accommodation doesn't ultimately deliver a coherent discourse. In both of these cases, accommodation fails with respect to the previous discourse context, but then succeeds within the sentence. Incoherence only follows because the resulting structure cannot finally be attached to the previous discourse context.

First, take (1,2b).

- (1) The backbenchers were in revolt.  
 (2) b. ?Major launched a charm offensive before they were pacified.

We have observed that (2b) denotes the same temporal structure as (2a), but that it seems incoherent in the context of (1). Here, we provide one way to account for why the presupposition fails.

The SEDRS corresponding to (1) is  $\alpha$  and the SEDRS for (2b) is  $\beta_b$ .

- ( $\beta_b$ )  $\langle\{e_3, t_3\}, \{\text{charm}(a, b, e_3), \text{hold}(e_3, t_3),$   
 $t_3 \prec \text{now}, t_3 \prec t_2\},$   
 $\langle\{e_2, t_2\}, \{\text{pacified}(b, e_2), \text{hold}(e_2, t_2),$   
 $t_2 \prec \text{now}\}, \emptyset\rangle\rangle$

In the first stage of discourse attachment, we build the representation for  $\beta_b$  just given. In the second stage, we add its temporal implicatures. By IC2, we come to believe that the state of pacification doesn't just hold at  $t_2$ ; it starts there.

In the third stage, we attempt to deal with the presupposed part of  $\beta_b$ . Let  $\gamma$  be the presuppositional clause corresponding to  $e_2$  (the pacification), and  $\delta$  the matrix corresponding to  $e_3$  (the charming).  $\gamma$  will fail to bind to  $\alpha$ . Can it attach? We assume  $\langle\alpha, \alpha, \gamma\rangle$ , and so the line of reasoning is exactly that used in (7), and so no discourse relation can be found.

Having failed to attach the presupposition at the higher level, we attempt to attach it to its own matrix clause. We assume  $\langle\tau, \delta, \gamma\rangle$ , and find that Narration, States Overlap and the Charm Law apply. The Charm Law's conclusion follows by the Penguin Principle, i.e.,  $e_3$  causes  $e_2$ ; and by a further application of the principle, we conclude that a *Result* relation holds between  $\delta$  and  $\gamma$ . Call the resultant SDRS  $\epsilon$ .

At the final stage of processing, we must attach  $\epsilon$  to the prior discourse— $\alpha$ . Which rules apply when attaching  $\epsilon$  to  $\alpha$ ?  $\langle\tau, \alpha, \epsilon\rangle$  is added to the reader's KB, and so Narration, States Overlap and the Revolt Law all apply. To properly discuss this case, we introduce here a further law that will apply: one which reflects the Gricean maxim 'Be Orderly'. In Lascarides, Asher and Oberlander (1992:4–5), we presented a rule that constrained orderly text with respect to causation: the law reflected the intuition that one should not describe things in the order cause-effect-further causes of that effect, or effect-cause-further

effect of that cause. Here, we offer a generalisation of this law. Suppose we define two eventualities presented in a text as *conceptually immediate* if (a) one causes the other, and (b) the clauses that describe them are discourse-related. Then the pragmatic maxim below captures the intuition that nothing described elsewhere in a text should come between two conceptually immediate events.

• **Conceptual Immediacy:**

$$\begin{aligned} \langle \tau, \alpha, \beta \rangle \wedge \beta \rightarrow \text{Result}(\gamma, \delta) > \\ \neg(e_\gamma \prec \text{ibd}(e_\alpha) \prec e_\delta) \wedge \\ \neg(e_\gamma \prec \text{fbd}(e_\alpha) \prec e_\delta) \end{aligned}$$

In words, Conceptual Immediacy states that if the constituent  $\beta$  is to be attached to  $\alpha$ , where  $\beta$  contains  $\text{Result}(\gamma, \delta)$  (and so  $e_\gamma$  causes  $e_\delta$ ), then the start of  $e_\alpha$  (i.e.,  $\text{ibd}(e_\alpha)$ ) and the end of  $e_\alpha$  (i.e.,  $\text{fbd}(e_\alpha)$ ), cannot come inbetween  $e_\gamma$  and  $e_\delta$ .

Conceptual Immediacy has an impact on the analysis of (2b), because it applies in the attachment of  $\epsilon$  to  $\alpha$ , together with the laws we have already mentioned. Here, Conceptual Immediacy means that normally, the point where the revolt starts or finishes cannot come in between the charm offensive and the pacification. States Overlap means that normally, the revolt overlaps with the event structure described in  $\epsilon$ . So States Overlap and Conceptual Immediacy together say that normally, the revolt starts before the charm offensive, and continues until at least after the pacification has started. But this would mean that the revolt and pacification overlap, and this contradicts the Revolt Law. Thus Conceptual Immediacy and States Overlap on the one hand, and the Revolt Law on the other, are in irresolvable conflict, since the antecedents of these laws are unrelated. So no conclusions about discourse structure can be inferred, leading to incoherence.

Under this analysis, (2b) is coherent in isolation, but incoherent in the context of (1). The notion of orderliness in discourse plays a crucial role in this explanation: eventualities that are causally connected preclude other eventualities described in the discourse from intervening between them.

The other case of incoherence involves the connective *when*:

- (1) The backbenchers were in revolt.
- (2) d. ?Major launched a charm offensive when they were pacified.

The SEDRS corresponding to (1) is  $\alpha$ , and in the first stage of processing, we build the SEDRS  $\beta_d$  as the representation of (2d):

$$\begin{aligned} (\beta_d) \quad \{ \{e_3, t_3\}, \{ \text{charm}(a, b, e_3), \text{hold}(e_3, t_3), \\ t_3 \prec \text{now} \}, \\ \{ \{e_2, t_2\}, \{ \text{pacified}(b, e_2), \text{hold}(e_2, t_2), \\ t_2 \prec \text{now} \}, \emptyset \} \} \end{aligned}$$

In the second stage, we add its temporal implicatures: by No Cause,  $\neg \text{cause}(e_3, e_2)$  is added to the matrix clause  $\delta$ . This means that the charming

didn't cause the pacification; apart from anything else, this implicature renders (2d) an inappropriate vehicle for a speaker who wished to describe the course of events  $E_1$  we have been discussing.

In the third stage of processing, as with (2b), both binding and accommodating  $\gamma$  to  $\alpha$  fail, and so we assume  $\langle \tau, \delta, \gamma \rangle$ . The laws that apply are: Narration, States Overlap and the Charm Law. The Charm Law is the most specific, but its consequent is inconsistent with what is already known concerning causal structure. Thus, States Overlap, which is the next most specific law, wins. So we infer  $\text{Background}(\delta, \gamma)$ . Call the resultant SDRS  $\epsilon$ . We must now assume  $\langle \alpha, \alpha, \epsilon \rangle$ . The rules that apply are: Narration, States Overlap and the Revolt Law. Notice that in contrast to (2b), Conceptual Immediacy no longer applies, because  $\epsilon$  doesn't entail  $\text{Result}(\gamma, \delta)$ . Given the temporal structure entailed in  $\epsilon$ , the consequent of States Overlap would entail that the revolt and pacification overlap. But the Revolt Law entails the opposite. So a Nixon Diamond crystallises and the discourse is incoherent.

From examining (1,2b) and (1,2d), it should be apparent that managing to accommodate a presupposition by discourse attaching it to its matrix is not in itself sufficient for discourse coherence. The SDRS formed must still be attached within the preceding discourse context. It is this second attachment that fails to occur in these cases. Both Conceptual Immediacy and No Cause can yield discourse incoherence. In (2d), for example, if it weren't for No Cause, the Charm Law would have won during accommodation instead of States Overlap. This would have changed the set of laws which apply when attaching  $\epsilon$  to  $\alpha$ , leading to different inferences about the discourse.

### 8.3 Temporal addition with coherence

Now consider text (3,4a):

- (3) I'm not a useless driver.
- (4) a. I could drive before you were born.

The logical forms of the two sentences are respectively  $\alpha$  and  $\beta_a$ :

$$\begin{aligned} (\alpha) \quad [e_1, t_1][\neg \text{useless-driver}(a, e_1), \text{hold}(e_1, t_1), \\ t_1 \prec \text{now}] \\ (\beta_a) \quad \{ \{e_2, t_2\}, \{ \text{can-drive}(a, e_2), \text{hold}(e_2, t_2), \\ t_2 \prec \text{now}, t_2 \prec t_3 \}, \\ \{ \{e_3, t_3\}, \{ \text{born}(b, e_3), \text{hold}(e_3, t_3), \\ t_3 \prec \text{now} \}, \emptyset \} \} \end{aligned}$$

Now, in the first stage of processing, we build the SEDRS just given. In the second stage, we add the temporal implicatures, and find that being able to drive didn't just hold at  $t_2$ , it started there.

In the third stage, we deal with the presupposition. Call the third sub-part of the SEDRS  $\gamma$ .  $\gamma$  can't bind to the context, and so we assume  $\langle \alpha, \alpha, \gamma \rangle$ , and the laws that apply are: Narration and States Overlap. But inferring *Background* via the Cascaded Penguin



Principle is blocked in this case by WK that conflicts with Background's constraints on topic structure: WK dictates that no distinct common topic for *a* being able to drive and *b* being born can be found. Similarly, *Narration* can't be inferred because it imposes the same constraints on topic structure as *Background*. These constraints on topic structure explain why the discourse (8) is incoherent.

(8) ?I'm not a useless driver. You were born.

So discourse attachment of  $\gamma$  to  $\alpha$  fails. Consequently, we then attempt accommodation by attaching  $\gamma$  to  $\delta$  with a discourse relation. This fails for similar reasons: a common topic can't be found. Therefore, since accommodation via discourse attachment has failed, we attempt accommodation via temporal addition. In effect, we try to interpret the subordinate clause as a temporal adverb, like *before 1962*. We first try to add the discourse referents in  $\gamma$  and their conditions to  $\alpha$ : this succeeds, since there are no logical inconsistencies. The result is the following DRS  $\epsilon$ :

( $\epsilon$ )  $[e_1, t_1, e_3, t_3][\neg \text{useless-driver}(a, e_1),$   
 $\text{hold}(e_1, t_1), t_1 \prec \text{now},$   
 $\text{born}(b, e_3), \text{hold}(e_3, t_3),$   
 $t_3 \prec \text{now}]$

Having successfully accommodated, we proceed to the fourth stage of processing: we attempt to attach the matrix clause  $\delta$  to  $\epsilon$ :

( $\delta$ )  $[e_2, t_2][\text{can-drive}(a, e_2), \text{hold}(e_2, t_2),$   
 $t_2 \prec \text{now}]$

The rules that apply are: *Narration* and *States Overlap*. By the Cascaded Penguin Principle, *Background* is inferred. Note that this time, a common topic can be found between the constituents: it is the driving ability of *a*.

In this example, there was failure to accommodate via discourse attachment, but the text was eventually predicted to be coherent. This contrasts with (1,2b), where accommodation via discourse attachment was successful, but the text was eventually predicted to be incoherent. This indicates that success in the early stages of processing doesn't guarantee coherence; nor does failure in the first attempt to accommodate guarantee incoherence.

#### 8.4 Binding with incoherence

We finally provide an example where the presupposition is bound, and the resultant discourse is incoherent:

(3) I'm not a useless driver.

(4) b. ?You were born after I could drive.

The SEDRS representing (3) is  $\alpha$  above, and the SEDRS representing (4b) is  $\beta_b$ :

( $\beta_b$ )  $\{\{e_3, t_3\}, \{\text{born}(b, e_3), \text{hold}(e_3, t_3),$   
 $t_3 \prec \text{now}, t_3 \prec t_2\},$   
 $\{\{e_2, t_2\}, \{\text{can-drive}(a, e_2), \text{hold}(e_2, t_2),$   
 $t_2 \prec \text{now}\}, \emptyset\}\}$

In the first stage of processing, we build the SEDRS just given. In the second stage, we add the temporal implicatures, and find that being able to drive doesn't just hold at  $t_2$ , it starts there.

In the third stage, we deal with the presupposition. We assume here that the Identify Drive Law forms part of the reader's KB: it captures the intuition that not being a useless driver and being able to drive are one and the same eventuality:

#### • Identify Drive Law:

$\neg \text{useless-driver}(a, e) \leftrightarrow \text{can-drive}(a, e)$

Because of the Identify Drive Law, we can *bind* the presupposed material  $\gamma$  to  $\alpha$ . So we then go onto the fourth stage of processing, and attempt to attach the matrix clause  $\delta$ —which represents *you were born*—to  $\alpha$ . By the constraints on topic structure imposed by Background and Narration, attachment of  $\delta$  to  $\alpha$  fails, for just the same reasons as it did before. Here, in contrast to (3,4a), the violation of the topic constraints is fatal, because *you were born* is a main clause. It cannot be reinterpreted as a temporal adverbial when discourse attachment has failed.

## 9 Conclusion

By concentrating on a simple but pervasive phenomenon concerning the interpretation of temporal connectives, we have extended a formal mechanism to show how interacting discourse context, WK and LK determine which presupposed eventualities can be accommodated. The way in which accommodation is handled depends on the content of the presupposed clause, and we pointed to some interesting behaviour in this connection.

On the one hand, when accommodation by discourse attachment fails, accommodation by temporal addition can still succeed. In such cases, a purely temporal reading of the subordinate clause is forced, and this leads to very weak coherence constraints for the discourse as a whole. These weak constraints are akin to those in classical treatments of temporal connectives in DRT; however, our analysis still differs somewhat, eschewing as it does reference times. On the other hand, even when accommodation by discourse attachment succeeds, there is no guarantee that the text is coherent; presupposition accommodation is a necessary, but insufficient, part of the process of discourse structure retrieval.

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